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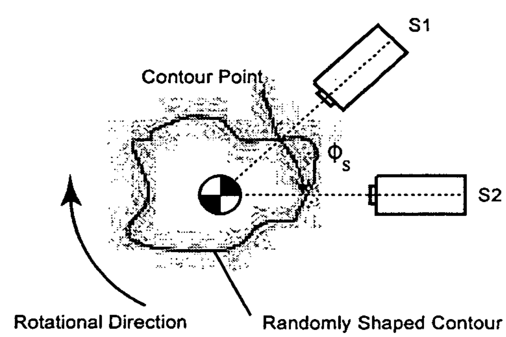
(54) Revolution counter for determining revolution speeds and accelerations at rotating parts having any random contour

(57) Using this device it is now possible to measure, with great accuracy and without any auxiliary elements (dividing disks) or any revolution acceleration sensors (such as piezoelectric pick-ups), the revolution speed and acceleration at rotating contours of any shape that have a fixed rotational axis. To this effect, two sensors (such as inductive or capacitive sensors) are used. The two sensors are arranged radially at a fixed but randomly adjustable angle to the rotational axis of the rotating contour, and measure the time required by a randomly chosen contour point to travel between the two sensors. In this way, a random contour point generates a measuring signal M1 at sensor S1 at time t_1, followed by a chronologically staggered measuring signal M2 at time t_2 at sensor S2, said measuring signal M2 being at a level equal to that of the measuring signal M1. The time t_1 - t_2 so measured is a measurement of the instantaneous RPM's and thus of the revolution speed itself.



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The following information was taken from the documentation submitted by the applicant.

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Specification

The invention comes from the field of metrology.

Conventional RPM counters are dependent on the contour of the rotating object being measured and are currently limited to measuring the number of revolutions on rotating gear wheels having a fixed rotational axis. However, the resultant readings are affected by factors such as the shape of the teeth, faulty tooth pitches, and other manufacturing tolerances. For this reason, the measurements are not directly taken at the gear wheel—the object being measured—, but rather indirectly, using a very precise dividing disk that is fixedly and coaxially connected to the object being measured. To this effect, the impulses of the dividing disk within a specific period are counted to determine the revolutions per minute. The accuracy of the measurement is dependent on the pitch error of the dividing disk, and its resolution depends on the degree of resolution of the dividing disk. Due to their significant manufacturing costs, high-resolution dividing disks are very expensive.

The manufacturers of such measuring systems include:

— IRION & VOSSELER GmbH & CO

— SONY (Magnescale system)

— ROTEC GmbH Testsystems for machine manufacturing.

The problem involves measuring the revolution speed and acceleration at rotating gear wheels in transmission housings. This is possible only by means of the dividing disks described in the second paragraph above or by means of revolution acceleration sensors that for lack of space cannot be used in applications such as vehicle transmissions. Furthermore, in the case of revolution acceleration sensors, the measured signal must be picked up from the rotating part through sliding contacts or telemetry, and this is precluded by the extremely compact design.

The invention for which the patent claims seek protection comprises a measuring instrument by means of which revolution speeds and accelerations can be measured without touching the object being measured. The rotating object can have any contour (see **Fig.** 1). This means that gear wheels, for example, can have errors in pitch or form, yet will not adversely affect the RPM's measured.

The invention comprises two sensors that scan the contour of the part rotating on a fixed rotational axis without coming into contact with it. The sensors pick up the RPM's and convert them to two electrical measuring signals (M1, M2). The RPM's can be determined based on the phase relationship of these measuring signals (see **Fig.** 2). The two sensors S1 and S2 are arranged radially at a fixed but randomly adjustable angle to the rotational axis of the rotating contour (see **Fig.** 1), and the time required by any randomly chosen contour point to travel between the two sensors is measured. In this way, a random contour point generates a measuring signal M1 at sensor S1 at time t_1, followed by a chronologically staggered measuring signal M2 generated at time t_2 at sensor S2, said measuring signal M2 being at a level equal to that of the measuring signal M1 (see **Fig.** 2). The time $t_1 - t_2$ so measured is a measurement of the instantaneous RPM's and thus of the revolution speed itself. The measurement always occurs at the same contour point and is thus independent of the overall contour of the rotating part. Changes in the relative revolution speed (revolution acceleration) can be determined without knowing the sensor angle ϕs (see **Figs.** 1 and 3) of the sensors. The absolute RPM's can be easily determined by measuring the sensor angle ϕs.

This device now makes it possible, using only two sensors, to measure RPM's and revolution speeds, as well as revolution accelerations on parts that rotate on a fixed rotational axis. The measurement is done at the object itself (see **Fig.** 3). One application is the precise measurement of RPM's directly at vehicle transmission gear wheels.

The new RPM counter dispenses with the expensive dividing disk until now in use. It allows for a very high measurement resolution that depends only on the scan rate of the pickup system of the values measured. Since the measurement is independent of the contour of the object being measured, any type of rotating contour can be measured using this device. Because the measurements are taken directly at the object, even revolution accelerations can be determined without errors.

A Possible Embodiment

Two inductive pickups are used to scan the contour of any random gear wheel without coming into contact with it (see **Fig.** 3). Using a measuring card (A-D converter) and a PC, the readings (the voltage signals of the sensors S1 and S2) are recorded and evaluated by means of a software program (see block wiring diagram, **Fig.** 4). The design was realized. By way of example, **Fig.** 5 shows the RPM sequence measured by this application on a chain wheel with irregular pitch and different tooth heights. The clearly visible break in the RPM sequence (first order) can be attributed to an imbalance of the gear wheel. This application makes it possible to measure the fluctuations in the revolution speed within a range of approximately 0.5% and confirms the merits of the measuring instrument.

Claims

1. Revolution counter for determining revolution speeds and accelerations on rotating parts having any contour, **characterized in that** two sensors which scan, without touching, the contour of the part that rotates on a fixed rotational axis, pick up said contour and convert it to two electrical measuring signals, the phase relationship of which allows the revolution speed to be determined. The two sensors are arranged radially at a fixed but randomly adjustable angle to the rotational axis of the rotating contour, and the time required by any randomly chosen contour point to travel between the two sensors is measured. In this way, a random contour point generates a measuring signal M1 at sensor S1 at time t_1, followed by a chronologically staggered measuring signal M2 generated at time t_2 at sensor S2, said measuring signal M2 being at a level equal to that of the measuring signal M1. The time $t_1 - t_2$ so measured is a measurement of the instantaneous RPM's and thus of the revolution speed itself. The measurement always occurs at the same instantaneous contour point and is thus independent of the overall contour of the rotating part.

2. Revolution counter according to claim 1, **characterized in that** it allows revolution speeds and accelerations to be measured at randomly shaped, rotating gear wheels on a fixed rotational axis such as are used in transmissions, by the simple affixing of only two measuring sensors. Faulty gear wheel tooth shapes or pitches have no effect on the revolution speeds or accelerations measured.

5 Pages of Drawings Accompany this Specification.

Morningside Evaluations and Consulting

TRANSLATOR CERTIFICATION

I, Carol Meyers, a translator fluent in the German language, on behalf of Morningside Evaluations and Consulting, do solemnly and sincerely declare that the following is, to the best of my knowledge and belief, a true and correct translation of the document(s) listed below in a form that best reflects the intention and meaning of the original text.

MORNINGSIDE EVALUATIONS AND CONSULTING

Carol Meyers

Signature of Translator

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